North Coast Watershed Assessment Program

DRAFT

Mattole Watershed Synthesis Report

The mission of the North Coast Watershed Assessment Program is to conserve and improve California's north coast anadromous salmonid populations by conducting, in cooperation with public and private landowners, systematic multi-scale assessments of watershed conditions to determine factors affecting salmonid production and recommend measures for watershed improvements.

Public Review Draft - March 22, 2002

Program Introduction and Overview

North Coast Watershed Assessment Program (NCWAP)

Salmon / Stream / Watershed / Land Use Relationships

Anadromous Pacific salmonids are dependant upon a high quality freshwater environment at the beginning and end of their life cycles. As such, they thrive or perish depending upon the availability of cool, clean water, free access to migrate up and down their natal streams, clean gravel for successful spawning, adequate food supply, and protective cover to escape predators and ambush prey. These life requirements must be provided by diverse and complex instream habitats as the fish move through their life cycles. If any of these elements are missing or in poor condition at the time a fish or stock requires it, their survival can be impacted. These life requirement conditions can be identified and evaluated on a spatial and temporal basis at the stream reach and watershed levels. They comprise the factors that support or limit salmonid stock production.

“In streams where fish live and reproduce, all the important factors are in a suitable (but usually not optimum) range throughout the life of the fish. The mix of environmental factors in any stream sets the carrying capacity of that stream for fish, and the capacity can be changed if one or more of the factors are altered. The importance of specific factors in setting carrying capacity may change with life stage of the fish and season of the year,” (Bjorrn and Reiser, 1991).

Through the course of the years, natural climatic, watershed hydrologic responses, and erosion events interact to shape freshwater salmonid habitats. These include the kind and extent of the watershed’s vegetative cover as well, and act to supply nutrients to the stream system. “In the absence of major disturbance, these processes produce small, but virtually continuous changes in variability and diversity against which the manager must judge the modifications produced by nature and human activity. Major disruption of these interactions can drastically alter habitat conditions.” (Swanston, 1991).

The results of a major disruption, which can be created over time by many smaller disruptions, can drastically alter instream habitat conditions and the aquatic communities that depend upon them. Thus, it is important to understand the critical, dependent relationships of salmon and steelhead with their natal streams during their freshwater life phases, and their streams’ dependency upon the watersheds within which they are nested, and the energy of the watershed processes that binds them together.

“Protection and maintenance of high-quality fish habitats should be among the goals of all resource managers. Preservation of good existing habitats should have high priority, but many streams have been damaged and must be repaired. Catastrophic natural processes that occlude spawning gravels can reduce stream productivity or block access by fish (for example), but many stream problems, especially in western North America, have been caused by poor resource management practices of the past. Enough now is known about the habitat requirements of salmonids and about good management practices that further habitat degradation can be prevented, and habitat rehabilitation and enhancement programs can go forward successfully,” (Meehan, 1991).

In general, natural disruption regimes do not impact larger watersheds, like the 300 square mile Mattole, in their entirety at any given time. Rather, they rotate episodically across the entire mosaic of their smaller subbasin, watershed, and sub-watershed components over long periods of time. This creates a shifting mosaic of habitat conditions over the larger watershed, (Reice, 1994).

Human disturbance sites, although individually small in comparison to natural disturbance events, are usually spatially distributed widely across basin level watersheds (Table 1, (Reeves, et al. 1995). For example, a rural road or building site is an extremely small land disturbance in relationship to a forty-acre landslide or a wildfire covering several square miles. However, when all the roads in a basin the size of the 300 square mile Mattole are looked at collectively, their disturbance effects are much more widely distributed than a single large, isolated landslide that has a high, but relatively localized impact to a single sub-watershed.

Generally, large watershed areas at the basin or regional levels experience these large, isolated events across the mosaic of their watershed sub-units on a rotating basis. This assures that at least some streams in a region or basin will be in suitable condition for salmonid stocks. A dramatic, large-scale example occurred in May, 1980 in the Toutle River, Washington, which was inundated in slurry when Mt. St. Helens erupted. The river rapidly became unsuitable for fish. In response, returning salmon avoided the river that year and used other nearby and suitable streams on an opportunistic basis, but returned to the Toutle two years later as conditions improved. This return occurred much sooner than had been initially expected.

Human disturbance regimes collectively extend across basin and even regional scales and have lingering effects. Examples include water diversions, conversion of near stream areas to urban usage, removal of large, mature vegetation, widespread soil disturbance leading to increased erosion rates, construction of levees or armored banks that can disconnect the stream from its floodplain, and the installation of dams and reservoirs that disrupt normal flow regimes and prevent free movement of salmonids and other fish. These impacts often develop in concert and in an extremely short period of time on the natural, geologic scale.

This rapid development rate occurs because developing technology and market driven land uses tend to occur in temporal waves, like the California Gold Rush or the post-WWII logging boom in Northern California. The intense human land use of the last century, combined with the transport energy of two mid-century, record floods on the North Coast, created stream habitat impacts at the basin and regional scales. The result has overlain the natural disturbance regime and depressed stream habitat conditions across most of the North Coast region. Consequently, the collective affect of human disturbance has lowered the disturbance regime "ceiling" across the north coast region and depressed stream habitat quality and quantity in general. It is within this impacted environment that natural disturbances continue to occur, but without the plenitude of robust refugia "lifeboats" that were historically available.

Table 1: Watershed Disturbance Regimes (Reeves, 2001).

Disturbance Affects	Natural Disturbances	Man-Caused Disturbances
Magnitude	High	Low, Medium
Frequency	Low	High
Area	Small to Intermediate	Large
Coupling of System	Maintains	Decouples
Legacy	Wood, Sediment	Sediment

Although no long term fish counts exist for the Mattole River, Department of Fish and Game fish ladder counts at Benbow Dam and Cape Horn Dam, in the neighboring Eel River system, reflect over an eighty percent decline in coho salmon, chinook salmon, and steelhead trout populations over the span of the last century (Figure 1). The Eel, especially the nearby South Fork that contains Benbow Dam, has similar conditions and land use history to the Mattole. Anecdotal evidence from anglers and longtime local residents supports the likelihood of a similar decline in the Mattole fisheries (see Mattole Profile). Since 1980, due in large part to collaborative work between the Department of Fish and Game and the Mattole Salmon Support Group, there is a record of very low coho and chinook salmon populations, and depressed steelhead trout populations.

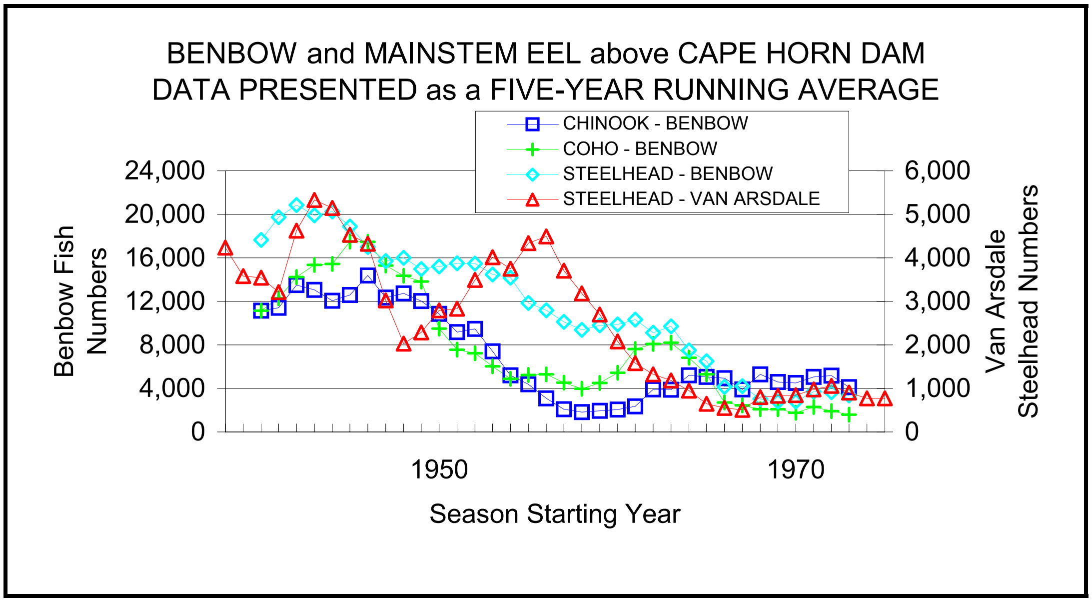


Figure 2: Five-Year Running Average of salmonids at Benbow and Mainstem Eel above Cape Horn Dam.

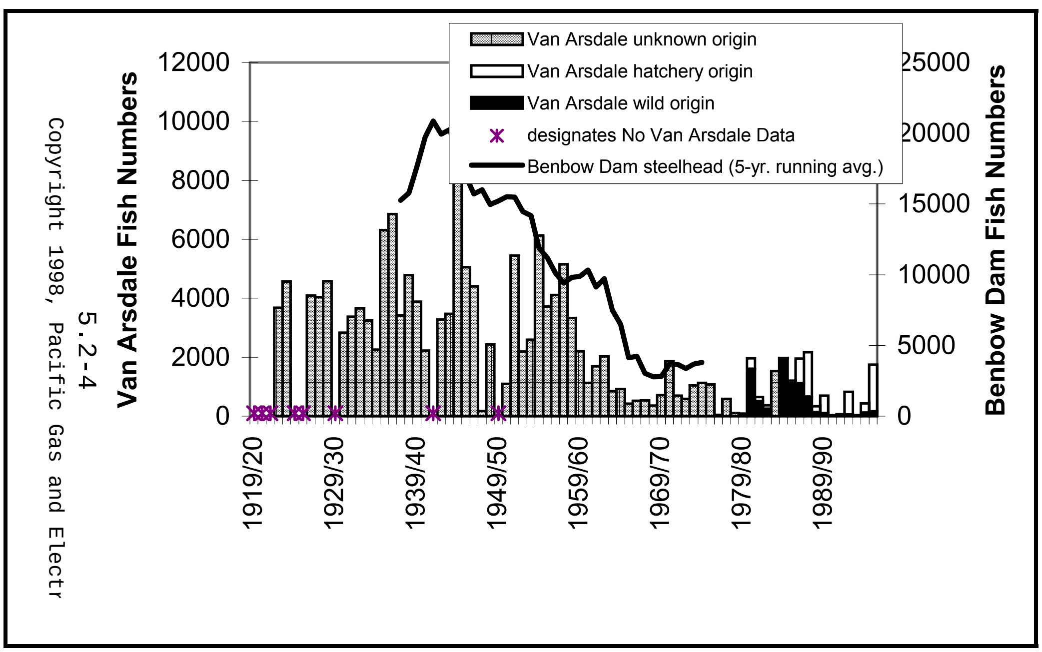


Figure 3: Historical Steelhead Trout Ladder Counts at Van Arsdale Fisheries Station and Benbow Dam.

Factors Affecting Anadromous Salmonid Production

Chinook salmon, coho salmon, and steelhead trout all utilize headwater streams, larger rivers, estuaries and the ocean for parts of their life history cycles. There are several factors necessary for the successful completion of an anadromous salmonid life history.

A main component of the NCWAP is the analyses of these factors in order to identify whether any of them are at a level that limits production of anadromous salmonids in North Coast watersheds. This "limiting factors analysis" (LFA) provides a means to evaluate the status of a suite of key environmental factors that affect anadromous salmonid life history.[1] These analyses are based on comparing measures of habitat components such as water temperature and pool complexity to a range of reference conditions determined from empirical studies and/or peer reviewed literature. If the component's condition does not fit within the range of the reference values, it may be viewed as a limiting factor. This information will be useful to identify the underlying causes of stream habitat deficiencies and help reveal if there is a linkage to watershed processes and land use activities.

In the freshwater phase in salmonid life history, stream connectivity, stream condition, and riparian function are essential for survival. Stream connectivity describes the absence of barriers to the free instream movement of adult and juvenile salmonids. Free movement in well-connected streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity.

Stream condition includes several factors. They include adequate stream flow, suitable water quality, suitable steam temperature, and complex habitat. For successful salmonid production, stream flows should mimic the natural hydrologic regime of the watershed. A natural regime minimizes the frequency and magnitude of storm flows and promotes better flows during dry periods of the water year. salmonids evolved with the natural hydrograph of coastal watersheds, and changes to the timing, magnitude, and duration of low flows and storm flows can disrupt the ability of fish to follow life history cues. Adequate instream flow during low flow periods is essential for good summer time stream connectivity, and is necessary to provide juvenile salmonids free forage range, cover from predation, and utilization of localized temperature refugia from seeps, springs, and cool tributaries.

Three important aspects of water quality for anadromous salmonids are water temperature, turbidity, and sediment load. In general, suitable water temperatures for salmonids are between 48° and 56° F for successful spawning and incubation, and between 50-52° and 60-64° F, depending on species, for growth and rearing. Additionally, cool water holds more oxygen, and salmonids require high levels of dissolved oxygen in all stages of their life cycle.

A second important aspect of water quality is turbidity, which is the relative clarity of water. Water clarity and turbid suspended sediment levels affect nutrient levels in streams that in turn affect primary productivity of aquatic vegetation, and insect life. This eventually reverberates through the food chain and affects salmonid food availability. Additionally, high levels of turbidity interfere with juvenile salmonids' ability to feed and can lead to reduced growth rates and survival (B. Trush, personal communication).

[1] The concept that fish production is limited by a single factor or by interactions between discrete factors is fundamental to stream habitat management (Meehan 1991). A limiting factor can be anything that constrains, impedes, or limits the growth and survival of a population.

A third important aspect of water quality is stream sediment load. salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clays, and other fine sediment. Eggs and embryos suffocate under excessive fine sediment conditions because oxygenated water is prevented from passing through the egg nest, or "redd." Additionally, high sediment loads can "cap" the redd and prevent emergent fry from escaping the gravel into the stream at the end of incubation. High sediment loads can also cause abrasions on fish gills, which may be susceptible to infection. At extreme levels, sediment can clog the gills causing death. Additionally, materials toxic to salmonids can cling to sediment and be transported through the downstream areas.

Habitat complexity for salmonids is created by a combination of deep pools, riffles, and flatwater habitat types. Pools, and to some degree flatwater habitats, provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas, particularly for young coho salmon. They are also necessary for adult resting areas. A high level of fine sediment fills pools and flatwater habitats. This reduces depths and can bury complex niches created by large substrate and woody debris. Riffles provide clean spawning gravels and oxygenate water as it tumbles across them. Steelhead fry use riffles during rearing. Flatwater areas often provide spatially divided "pocket water" units that separate individual juveniles which helps promote reduced competition and successful foraging (Flosi, et al., 1998).

A functional riparian zone helps to control the amount of sunlight reaching the stream, and provides vegetative litter and invertebrate fall. These contribute to the production of food for the aquatic community, including salmonids. Tree roots and other vegetative cover provide stream bank cohesion and buffer impacts from adjacent uplands. Nearstream vegetation eventually provides large woody debris and complexity to the stream (Flosi et al. 1998).

Riparian zone functions are important to anadromous salmonids for numerous reasons. Riparian vegetation helps keep stream temperatures in the range that is suitable for salmonids by maintaining cool stream temperatures in the summer and insulating streams from heat loss in the winter. Larval and adult macroinvertebrates are important to the salmonid diet and they are in turn dependant upon nutrient contributions from the riparian zone. Additionally, stream bank cohesion and maintenance of undercut banks provided by riparian zones in good condition maintains diverse salmonid habitat, and helps reduce bank failure and fine sediment yield to the stream. Lastly, the large woody debris provided by riparian zones shapes channel morphology, helps a stream retain organic matter and provides essential cover for salmonids (Murphy and Meehan 1991).

Therefore, excessive natural or man-caused disturbances to the riparian zone, as well as the directly to the stream and/or the watershed itself can have serious impacts to the aquatic community, including anadromous salmonids. Generally, this seems to the case in streams and watersheds in the north coast of California. This is borne out by the recent decision to include many North Coast chinook and coho salmon, and steelhead trout stocks on the Endangered Species Act list.

Policies, Acts, and Listings

Several federal and state statues have significant implications for watersheds, streams, fisheries, and their management. Here, we present only a very brief listing and description of several laws.

Federal Statutes

One of the most fundamental of federal environmental statutes is the **National Environmental Policy Act** (NEPA). NEPA is essentially an environmental impact assessment and disclosure law. Projects contemplated or plans prepared by federal agencies or funded by them must have an environmental assessment completed and released for public review and comment, including the consideration of more than one alternative. The law does not require that least impacting alternative be chosen, only that the impacts be disclosed.

The federal **Clean Water Act** has a number of sections relevant for watersheds and water quality. Section 208 deals with non-point source pollutants arising from silvicultural activities, including cumulative impacts. Section 303 deals with waterbodies that are impaired such that their water quality is not suitable for the beneficial uses identified for those waters. For water bodies identified as impaired, the US Environmental Protection Agency or its state counterpart (here, the North Coast Regional Water Quality Control Board and the State Water Resources Control Board) must set targets for "total maximum daily loads" (TMDLs) of the pollutants that are causing the impairment. Section 404 deals with the alterations of wetlands and streams through filling or other modifications, and requires the issuance of federal permits for most such activities.

The federal **Endangered Species Act** (ESA) addresses the protection of animal species whose populations are dwindling to critical levels. Two levels of species risk are defined. A "threatened" species is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. An "endangered" species is any species that is in danger of extinction throughout all or a significant portion of its range. In general, the law forbids the "take" of listed species. Taking is defined as harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting a species or attempting to engage in any such conduct. A take of a species listed as threatened may be allowed where specially permitted through the completion and approval of a Habitat Conservation Plan. A HCP is a document that describes how an agency or landowner will manage their activities to reduce effects on vulnerable species. A HCP discusses the applicant's proposed activities and describes the steps that will be taken to avoid, minimize, or mitigate the take of species that are covered by the plan. Many of California's salmon runs are listed under ESA, including the chinook and coho salmon found in the Mattole Basin. Steelhead, which are also found in the Mattole Basin, have been proposed for listing.

State Statutes

The state analogue of NEPA is the **California Environmental Quality Act** (CEQA). CEQA goes beyond NEPA in that is requires the project or plan proponent to select for implementation the least environmentally impacting alternative considered. When the least impacting alternative would still cause "significant" adverse environmental impacts, a statement of overriding considerations must be prepared.

The Porter-Cologne Water Quality Control Act establishes state water quality law and defines how the state will implement the federal authorities that have been delegated to it by the US EPA under the federal Clean Water Act. For example, the US EPA has delegated to the state certain authorities and responsibilities to implement TMDLs for impaired water bodies and NPDES (national pollution discharge elimination system) permits to point-source dischargers to water bodies.

Sections 1600 et seq. of the Fish and Game Code, implemented by the Department of Fish and Game, are required for any activities that alter the beds or banks of streams or lakes. This typically would be involved in a road project where a stream crossing was constructed. While treated as ministerial in the past, the courts have more recently indicated that these constitute discretionary permits and thus must be accompanied by an environmental impact review per CEQA.

The **California Endangered Species** Act (CESA). The California Endangered Species Act (CESA) (Fish & Game Code §§ 2050, *et seq.*) generally parallels the main provisions of the Federal Endangered Species Act and is administered by the California Department of Fish and Game (DFG). Coho salmon, found in the Mattole, is currently a candidate for listing under CESA. The State Fish and Game Commission is expected to make the final listing decision of this species in 2002.

The **Z'Berg-Nejedly Forest Practice Act** (FPA) and associated **Forest Practice Rules** establish extensive permitting, review, and management practice requirements for commercial timber harvesting. Evolving in part in response to water quality protection requirements established by the

1972 amendments to the federal Clean Water Act, the FPA and Rules provide for significant measures to protect watersheds, watershed function, water quality, and fishery habitat.

Assessment Needs for Salmon Recovery & Watershed Protection

The North Coast Watershed Assessment Program (NCWAP), an interagency effort between the California Resources Agency and CalEPA, was established in 2000 to provide a consistent scientific foundation for collaborative watershed restoration efforts and to better meet the State needs for protecting and restoring salmon species and their habitats under State and federal laws. The program was developed by a team of managers and technical staff from the following departments with watershed responsibilities for the North Coast: California Resources Agency, California Department of Fish and Game (DFG), California Department of Forestry and Fire Protection (CDF), California Department of Conservation/Division of Mines and Geology (DOC/DMG), California Department of Water Resources (DWR), and the North Coast Regional Water Quality Control Board (RWQCB) of the State Water Resources Control Board. The Institute for Fisheries Resources (IFR) is also a partner and participant in this program.

The California Resources Agency in coordination with the California Environmental Protection Agency, initiated NCWAP in part in response to specific requests from landowners and watershed groups that the State take a leadership role in conducting scientifically credible, interdisciplinary assessments that could be used for multiple purposes. The need for comprehensive watershed information grew in importance with listings of salmonids as threatened species, the Total Maximum Daily Load (TMDL) consent decree, and the increased availability of assistance grants for protecting and restoring watersheds.

Listings under the federal Endangered Species Act for areas within the NCWAP region (the North Coast Hydrologic Unit) began with coho salmon in 1997, followed by chinook salmon in 1999, and steelhead in 2000. In 2001, coho was proposed for listing under the California Endangered Species Act. Concerns about the potential impacts of salmonid listings and Total Maximum Daily Loads (TMDL) on the economy are particularly strong on the North Coast where natural-resource-dependent industries predominate. Cumulative impacts related to these activities, along with natural processes, can adversely affect watershed conditions and fish habitat, including landslides, flooding, timber harvest, mining, ranching, agricultural uses and development. In order to recover California's salmonid fisheries, it is necessary to first assess and understand the linkages among management activities, dominant ecological processes and functions, and factors limiting populations and their habitat.

NCWAP integrates and augments existing watershed assessment programs to conform with proven methodologies and manuals available from each department. The program also responds to recommendations from a Scientific Review Panel (SRP) which was created under the auspices of the State's Watershed Protection and Restoration Council as required by the March, 1998 Memorandum of Understanding (MOU) between the National Marine Fisheries Service (NMFS) and the California Resources Agency. The MOU required a comprehensive review of the California Forest Practice Rules (FPRs) with regard to their adequacy for the protection of salmonid species. In addition, the promise of significant new State and federal salmon restoration funds highlighted the need for watershed assessments to ensure those dollars are well spent.

NCWAP Program Goals

The NCWAP was developed to improve decision-making by landowners, watershed groups, agencies, and other stakeholders with respect to restoration projects and management practices to protect and improve salmonid habitat. It was therefore essential that the program took steps to ensure its assessment methods and products would be understandable, relevant, and scientifically credible. As a result, the interagency team developed the following goals:

1. Organize and provide existing information and develop limited baseline data to help evaluate the effectiveness of various resource protection programs over time;

2. Provide assessment information to help focus watershed improvement programs, and assist landowners, local watershed groups, and individuals to develop successful projects. This will help guide programs, like DFG's Fishery Restoration Grants Program, toward those watersheds and project types that can efficiently and effectively improve freshwater habitat and support recovery of salmonid populations;

3. Provide assessment information to help focus cooperative interagency, nonprofit and private sector approaches to "protect the best" watersheds and streams through watershed stewardship, conservation easements, and other incentive programs; and

4. Provide assessment information to help landowners and agencies better implement laws that require specific assessments such as the State Forest Practice Act, Clean Water Act, and State Lake and Streambed Alteration Agreements.

Program Objectives and Guiding Questions

During the assessment process, the NCWAP agencies will work together very closely at all stages to consider how man-caused and naturally occurring watershed processes interact and affect stream conditions for fisheries, and other uses, and also consider the implications for watershed management.

During the formulation of the NCWAP's Methods Manual, the participating agencies agreed upon a short list of critical questions with the key question being:

"What watershed factors are limiting salmonid populations?"

- What are the general relationships between natural event and land use histories, for example, fire, flood, drought, earthquake, etc.; and urban and rural land development, timber harvest, agriculture, roads, dams, and stream diversions. How is this history reflected in the current vegetation and level of disturbance in North Coast watersheds? How can these kinds of disturbances be meaningfully quantified?

- What is the spatial and temporal distribution of sediment delivery to streams from landsliding, bank, sheet and rill erosion, and other erosion mechanisms, and what are the relative quantities for each source?

- What are the effects of stream, spring, and groundwater uses on water quality and quantity?

- What role does large woody debris (LWD) have within the watershed in forming fish habitat and determining channel condition and sediment routing and storage?

- What are the current salmonid habitat conditions in the watershed, the aquatic/riparian zone, and the estuary (flow, water temperature/shade, sediment, nutrients, instream habitat, large woody debris and its recruitment); how do these compare to desired conditions (life history requirements of salmon, Basin Plan water quality objectives)?

- What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations and/or other aquatic community organisms within the watersheds?

- Does the status of these populations reflect current watershed and stream habitat conditions or does it indicate constraints beyond the watershed might exist. For example, a lack of stream connectivity that prevents free movement for adults or juveniles, or a poor marine life history, could affect a salmonid population.

These questions have guided the individual team members in data gathering and procedure assessment. The questions have provided direction for those analyses that required more interagency, interdisciplinary synthesis, including the analysis of factors affecting anadromous salmonid production.

Program Assessment Region and Agency Roles

The NCWAP assessment area includes all coastal drainages from Sonoma County north to Oregon. This area corresponds with the North Coast Water Quality Control Board's region. The region has been sub-divided into thirty-one basins for NCWAP assessment purposes (Map XX). Thus, the program will organize existing information and provide limited baseline environmental and biological information for approximately 6.5 million acres of land over an estimated seven-year period. The administrative lead for the NCWAP is the California Resources Agency

The roles of the five participating agencies in these efforts are as follows:

- DFG will compile, develop, and analyze data related to anadromous fisheries habitat and populations. It will also lead an interagency evaluation of factors affecting anadromous fisheries production at the watershed level and provide recommendations for restoration and monitoring in the final synthesis report.

- CDF will compile, develop, and analyze data related to historical land use changes in the watersheds. It will also take the lead on preparing reports that synthesize information, findings and recommendations, and develop a framework for assessing cumulative impacts.

- DOC/DMG will compile, develop, and analyze data related to the production and transport of sediment. Tasks will include baseline mapping of landslides, landslide potential, and instream sediment, as well as an analysis of stream geomorphology and sediment transport.

- RWQCB will compile, collect, and analyze water quality data for the assessments.

- DWR will install and maintain stream monitoring gages where needed to develop and analyze stream flow information.

Assessment Strategy and General Methods

Because the NCWAP is intended to provide information useful for several purposes, its approach emphasizes close coordination with clientele groups. The NCWAP products are expected to provide both context and content for finer scale analysis, set priorities for detailed analysis and program planning, and identify areas for further work. Therefore, although a relatively uniform assessment process will be followed in each basin, key issues and information are custom to each watershed. Variability in watershed condition, public resource values and concerns, land use and ownership, and the availability of existing data shape each assessment within the context of the guiding, critical questions. Public review of products will provide additional opportunities to adapt and enhance assessments in the future.

The steps of the NCWAP process in each basin are:

Step One: Scoping. The basin assessment team will meet with stakeholders to identify watershed problems or concerns, local assessment interests, existing data and gaps, and opportunities to work with local interests to answer the critical questions.

Step Two: Data compilation. The team will compile and screen existing data according to the quality and usefulness for answering critical questions and application to the program's Ecological Management Decision Support system model (EMDS). This model accepts information about the study watershed and /or stream, and helps process and explains relationships among current conditions affecting fishery production. Quality control processes are described in greater detail in Chapter 4 of the NCWAP's draft Method Manual. Mapping and geographical information system (GIS) presentation will be coordinated among the several departments.

Step Three: Initial Analyses. The team will use the EMDS model (described in Chapter 3 of the NCWAP's Methods Manual) to help analyze the habitat factors affecting fish production. This initial model run with existing data will help to identify significant data gaps (categories, location, and scale) and to focus field data verification and collection by DFG and others. The model will be updated and rerun as new data are collected and/or developed.

Step Four: Fieldwork. Agencies will conduct necessary fieldwork, including validation of existing data, verification of imagery or photo-based analyses, and collection of new data to fill critical gaps. Throughout this process, there will be coordination with local groups and landowners on access to private property and validation of findings.

Step Five: Analyze data. This includes the generation of maps, databases, and the more integrative analyses. Data will be analyzed in an interdisciplinary fashion where needed, particularly when answering critical questions, applying the limiting factors analysis, and developing general management and cumulative efforts recommendations.

Step Six: Develop Assessment Reports for Public Review: Draft products will include data developed or compiled by all the agencies as licenses or agreements permit (including photos and imagery); analytical products such as maps, limiting factor analysis results, GIS analyses, topical reports, etc.; and the review summary report with recommendations. These products will be made available in hard copy from NCWAP offices in Fortuna, Santa Rosa, and Sacramento; and also through the Klamath Resources Information System CD and on-line. A public review process will be established for each basin. The NCWAP team will summarize comments and revise preliminary products to reflect comments as feasible.

NCWAP Products

The NCWAP will produce and make available to the public a consistent set of products for each basin assessed. They include the following:

- Databases of information that the NCWAP has used and collected for its analysis. The NCWAP will also provide a data catalogue which identifies all the information we considered, and evaluates its usefulness for the NCWAP assessment process, as well as a bibliography of other references cited in the assessment report.

- Maps showing geology, geomorphic features related to landsliding, instream sediment and transport zones, and relative landslide potential developed by the Department of Conservation/Division of Mines and Geology.

- An Ecological Management Decision Support system (EMDS) model that describes how watershed conditions interact at the stream reach and watershed scale to affect suitability for fish.

- GIS-based models and analyses such as timber harvest frequency, road-based erosion model runs, vegetation, stream buffers, roads, road density, road and stream interactions, and roads on unstable slopes.

- An interdisciplinary analysis of the results of fieldwork, historical analyses, EMDS data, and other analytical products about the suitability of stream reaches and the watershed for salmonids.

- An interagency description of historic and current conditions as they relate to suitability for salmonid fisheries. This will address vegetation cover and change, land use, geology and geomorphology, water quality, streamflow and water use, and instream habitat conditions for salmonids. It will also contain hypotheses about watershed conditions that contribute to factors affecting salmonids.

- Recommendations for management and restoration to address limiting factors.

- Recommendations for additional monitoring to improve the assessment process.

- A CD developed through the Institute for Fisheries Resources (IFR) which uses the Klamath Resources Information System (KRIS) tool to store data, provide a regional bibliography of watershed studies and reports, present the NCWAP analyses, maps and other products, and store community based data over time.

- A synthesis report describing the results and implication of the watershed assessment.

All products will be made available electronically through the NCWAP website and the IFR's KRIS tool on CD and on their website.

Assessment Report Use and Conventions

Calwater 2.2a Planning Watersheds

NCWAP is using the California Watershed Map (CALWATER version 2.2a) to delineate watershed units. CALWATER is a set of standardized watershed boundaries meeting standardized delineation criteria. The hierarchy of watershed designations consists of six levels of increasing specificity: Hydrologic Region (HR), Hydrologic Unit (HU), Hydrologic Area (HA), Hydrologic Sub-Area (HSA), Super Planning Watershed (SPWS), and Planning Watershed (PWS). The primary purpose of Calwater is the assignment of a single, unique code to a specific watershed polygon. The Calwater Planning Watersheds are generally from 3,000 – 10,000 acres in size (see map on following page).

Primary purposes for Calwater 2.2 include but are not limited to mapping, reporting, and statistical analysis of water resources, water supply, water quality, wildlands, agriculture, soils, forests, rangelands, fish habitat, wildlife habitat, cross-referencing state and federal hydrologic unit or watershed codes and names.

CALWATER version 2.2 is the third version of Calwater (after versions 1.2 and 2.0), and is a descendent of the 1:500,000-scale State Water Resources Control Board Basin Plan Maps drawn in the late 1970's.

Tierra Data Systems completed Version 1.2 in 1995 by Tierra Data Systems (Jim Kellog). Line work was captured by overlaying the Basin Plan Maps on 1:24,000-scale USGS quad sheets, redrawing and digitizing lines to match 1:24,000-scale watershed boundaries, and subdividing the 4th level Hydrologic Subareas (HSA's) into 5th level Super Planning Watersheds (SPWS) and 6th level Planning Watersheds (PWS).

Mattole CalWater 2.2a Planning Watersheds

Hydrology Hierarchy

Watershed terminology often becomes confusing when discussing the different scales of watersheds involved in planning and assessment activities. The conventions used in the Mattole assessment follow the guidelines established by the Pacific Rivers Council. The descending order of scale is from ***basin*** level (e.g., Mattole Basin) – ***subbasin*** level (e.g., Northern subbasin) – ***watershed*** level (e.g., Honeydew Creek) – ***sub-watershed*** level (e.g., West Fork Honeydew Creek) (see map on following page).

The subbasin is the assessment and planning scale used in this report as a summary framework; subbasin findings and recommendations are based upon the more specific watershed and sub-watershed level findings. Therefore, there are usually exceptions at the finer scales to subbasin findings and recommendations. Thus, the findings and recommendations at the subbasin level are somewhat more generalized than at the watershed and sub-watershed scales. In like manner, subbasin findings and recommendations are somewhat more specific than the even more generalized, larger scale basin level findings and recommendations that are based upon a group of subbasins.

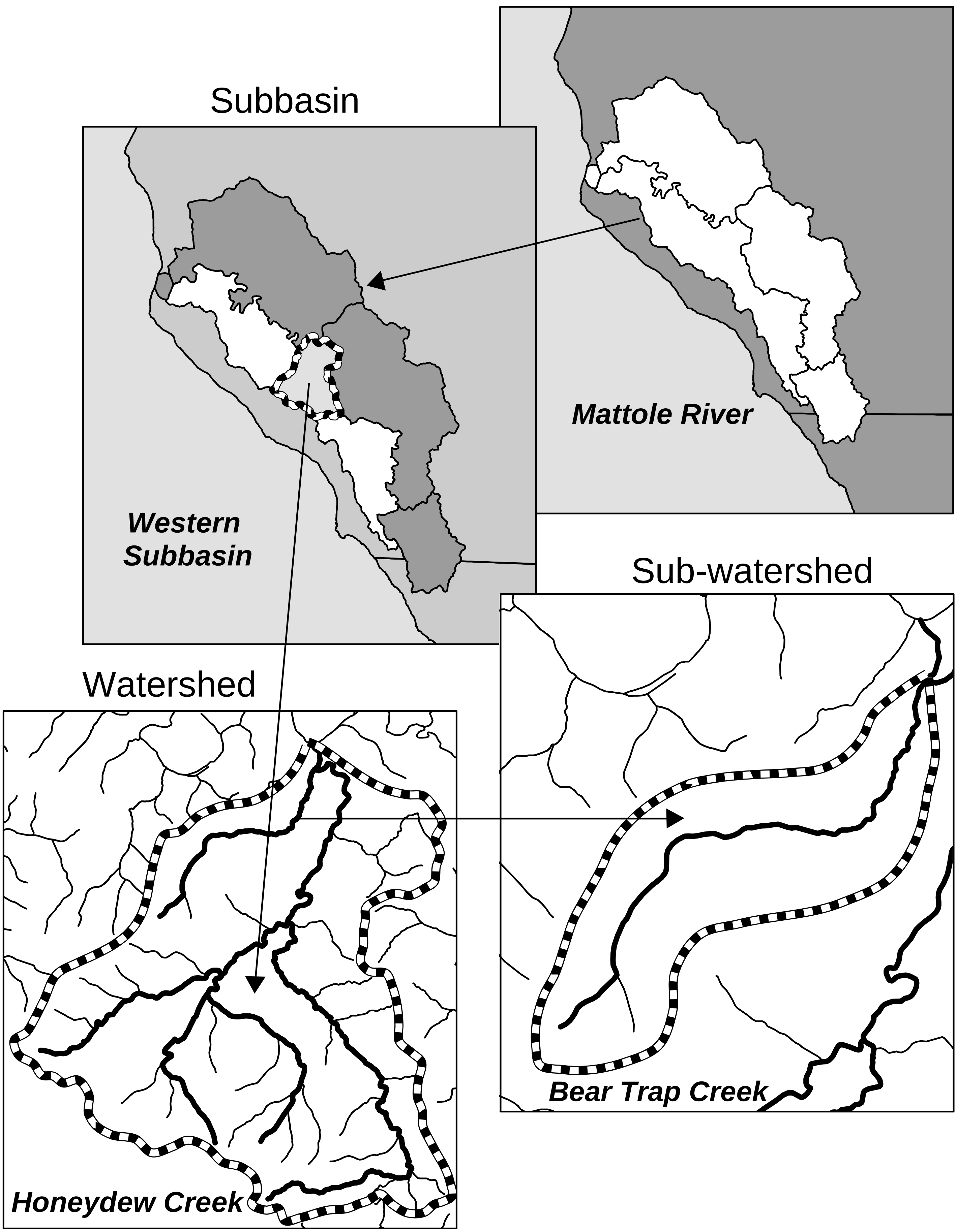
The term "watershed" is used in both the generic sense, as to describe "watershed" conditions at any scale, and as a particular term to describe the ***watershed*** scale introduced above, which contains, and is made up from multiple, smaller sub-watersheds. The watershed scale is often approximately 20 – 40 square miles in area; its sub-watersheds can be much smaller in area, but for our purposes contain at least one perennial, un-branched stream. Please be aware of this multiple usage of the term watershed, and consider the context of the term's usage to reduce confusion.

Report Utility and Usage

This report is intended to be useful to landowners, watershed groups, agencies, and individuals to help guide restoration, land use, and management decisions. As noted above, the assessment operates on multiple scales ranging from the detailed and specific stream reach level to the very general basin level. Therefore, findings and recommendations also vary in specificity from being particular at the finer scales, and general at the basin scale. In the Mattole River, for example, there is a general problem with elevated amounts of sediment in lower gradient stream channels. These are reaches used by chinook and coho salmon and steelhead trout. This sediment is generally harmful to salmonid habitat as discussed above, and further considered in the following discussion about the EMDS model (below). Today, this general elevated sediment condition is not uncommon throughout most of the overall NCWAP north coastal region. To improve upon that and other unsuitable conditions, and therefore salmonid habitat, will require long periods of time even with reduced levels of erosion brought about by careful watershed stewardship. A goal of this program is to help guide, and therefore accelerate that recovery process, by focusing stewardship and improvement activities where they will be most effective. Scaling down through finer levels guided by the recommendations should help accomplish this focus.

To do so, the report is constructed with section tabs to help provide guidance for that focus of effort. A user can scale down from the general basin finding and recommendation concerning high sediment levels, for example, to the various subbasin sections, to the stream reach level information to determine which streams in the subbasin may be affected by sediment. There is a list of surveyed streams in each subbasin section. In the general recommendation section, there is a tributary finding and recommendation summary table that indicates the findings and recommendations for the surveyed streams within the subbasin. If indicated, field investigations at the stream reach or project site level can be conducted to make an informed decision on a land use project, or to design improvement activities.

Hierarchy of Watersheds



For example in the Mattole's Eastern Subbasin, sediment is an issue in the findings and recommendations. From the list of tributaries in a subbasin section the tributary table can be referenced for potential project sites. For example, Westlund Creek is an Eastern Subbasin stream on that list that has both streambank and road-sourced erosion as issues for treatment related to land use projects or improvement activities. Interestingly, during the past two years, over seventy percent of the landowners in Westlund Creek gave permission for erosion control training and surveys to be conducted on their lands in cooperation with the Mattole Restoration Council and the DFG Restoration Grants Program. That effort was primarily based upon the recommendations in the 1996 DFG Westlund Creek Stream Report, which is summarized in this Report's DFG Appendix. The NCWAP, using these reports, other watershed assessments, its EMDS analytical tool and the resultant spatial presentations of its findings, will provide the opportunity to conduct better coordinated stewardship and improvement work like this example, but at the much broader, basin scale.

Ecological Management Decision Support (EMDS) Model

Introduction

NCWAP has chosen to use the Ecological Management Decision Support system model (EMDS) (Reynolds 1999) to help us evaluate and synthesize information on watershed and stream conditions for salmonids. The model does not address other factors such as marine habitat and fishery harvest. EMDS is an indicative model that helps to synthesize and explore a wide range of data. That is, it indicates what the quality of watershed or instream conditions are, based on available data and the model structure. It is not a highly rigorous process or statistical model intended to provide outputs with a known level of accuracy. Thus, we use EMDS as one tool, in conjunction with other information and analyses, to help identify the habitat factors that that are limiting the production of salmonids on North Coast Watersheds (see limiting factors discussion, above). To the extent possible, EMDS outputs should be compared to direct measures of salmonid production—i.e., the number of salmonids found in streams. While this section of the report describes in general how the EMDS model works, the basin profile, subbasin analyses, and EMDS Appendix of this report present the findings from running the model on the Mattole River, as well as more details about the model itself.

EMDS has a number of advantages for the assessment work NCWAP is conducting. First, rather than being an obscure "black box" model, EMDS has an explicit and intuitively understandable model structure. EMDS models can be easily modified to incorporate different data sets or different assumptions about what specific levels of specific factors (e.g., stream water temperature) are needed to provide suitable salmonid habitat. Further, since it is a spatial model, it can help us to understand how factors interact across a watershed to affect habitat. Therefore, its map-based outputs can clearly communicate model results. Finally, while the model produces a useful, overall watershed condition rating, highly specific information about the individual factors determining that overall condition can be gleaned from looking at the particular, supporting levels of the model. This specificity can help to identify those factors that are most limiting salmonid habitat and thus in most need of attention through restoration or modification of land use activities.

While EMDS has many advantages, the EMDS model we have developed and the data we are using to run it nonetheless have limitations. A section below documents these limitations. Note that the version of the EMDS model used in this report is preliminary. A scientist and resource professional review team is being empanelled, with help from the University of California, Berkeley, to help us strengthen the model. This revised model should be ready in time to utilize in the final draft of this report, which we expect to complete May 2002.

Details of the EMDS Model

EMDS is a “knowledge base” or “expert” system computer model. The knowledge base modeling software of EMDS requires scientists to identify and evaluate specific environmental factors or attributes, such as stream temperature and land use activities, which contribute to the formation of anadromous salmonid habitat. As such, EMDS provides a consistent and repeatable approach to evaluating conditions across watersheds. The spatial nature of EMDS makes it particularly useful for evaluating and portraying watershed and stream conditions.

This model employs a linked set of software that includes MS Excel, NetWeaver, Ecological Management Decision Support (EMDS) and ArcView™. Microsoft Excel is a commonly used spreadsheet program for data storage and analysis. NetWeaver (Saunders and Miller (no date)), developed at Pennsylvania State University, helps scientists build graphics of networks that specify how the various environmental factors are incorporated into an overall stream or watershed assessment. These networks resemble branching tree-like flow charts, and graphically show the logic and assumptions used in the synthesis.

EMDS (Reynolds 1999), was developed by Dr. Keith Reynolds at the USDA-Forest Service, Pacific Northwest Research Station. It uses the networks created with NetWeaver in conjunction with environmental data stored in a geographic information system (ArcView™) to perform the assessments and facilitate rendering the results into maps. This combination of Excel/NetWeaver/EMDS/ArcView software is currently being used for watershed assessment within the federal lands included in the Northwest Forest Plan.

The NCWAP’s development of its EMDS model began with a multi-day workshop organized by the University of California, Berkeley. In addition to the NCWAP staff, the workshop involved model developer Keith Reynolds and several invited scientists. As a starting point, the NCWAP used the EMDS knowledge base developed for use in coastal Oregon. Based on the workshop, subsequent discussions among the NCWAP staff and scientists, examination of the literature, and consideration of California conditions, the NCWAP developed its preliminary 1.1 version of the EMDS model, which is used in this report. As noted above, with further assistance from UC Berkeley, a team of scientists and resource professionals will review this preliminary model version and the data sets used in it. The NCWAP will then revise the model accordingly.

The Knowledge Base Network

For California’s north coastal watersheds, the NCWAP team built two knowledge base networks using the best available scientific studies and information on how various environmental factors combine to affect anadromous fish on the north coast. The first, called the Anadromous Reach Condition model (Figure 4), addresses conditions for salmon on individual stream reaches and is largely based on data collected under the Department of Fish and Game’s stream survey protocols. The second, the Watershed Condition model (Figure 5), serves as a framework for synthesis by watershed of a number of environmental factors in riparian and upland areas.

In creating both of these networks, the NCWAP scientists have used what is termed a ‘top-down’ approach. This approach is perhaps best explained by way of example. The model starts from the proposition that *the overall condition of a given watershed is suitable for maintaining healthy populations of native coho and chinook salmon, and steelhead trout*, and through the design of the knowledge base (the network) seek to evaluate the ‘truth’ of that assertion. We then constructed a knowledge base network to specify the types of information needed to test the proposition. That information focuses on the current condition of the many factors affecting salmonids, their streams, and watershed processes.

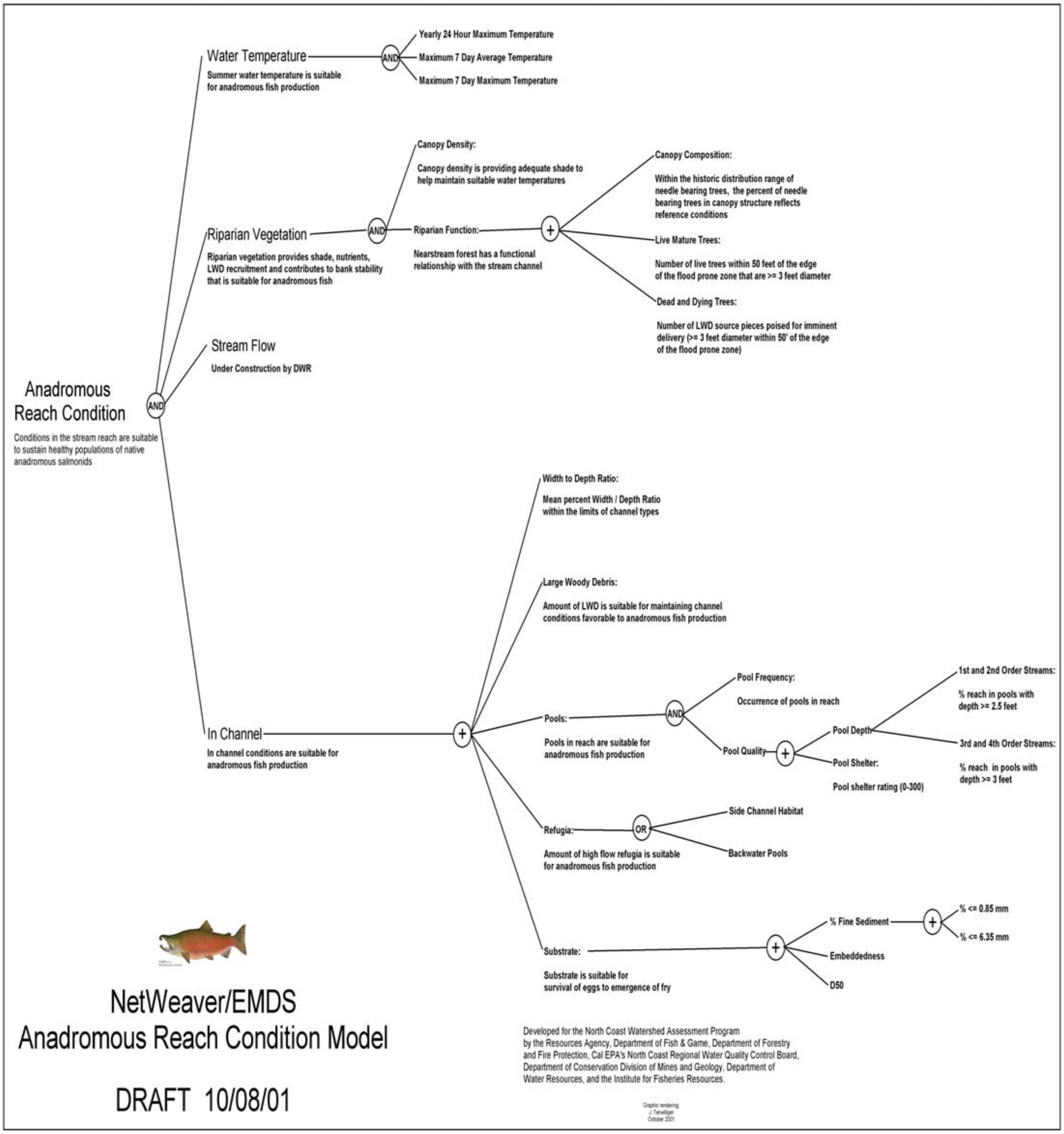


Figure 4: NCWAP EMDS Anadromous Reach Condition Model.

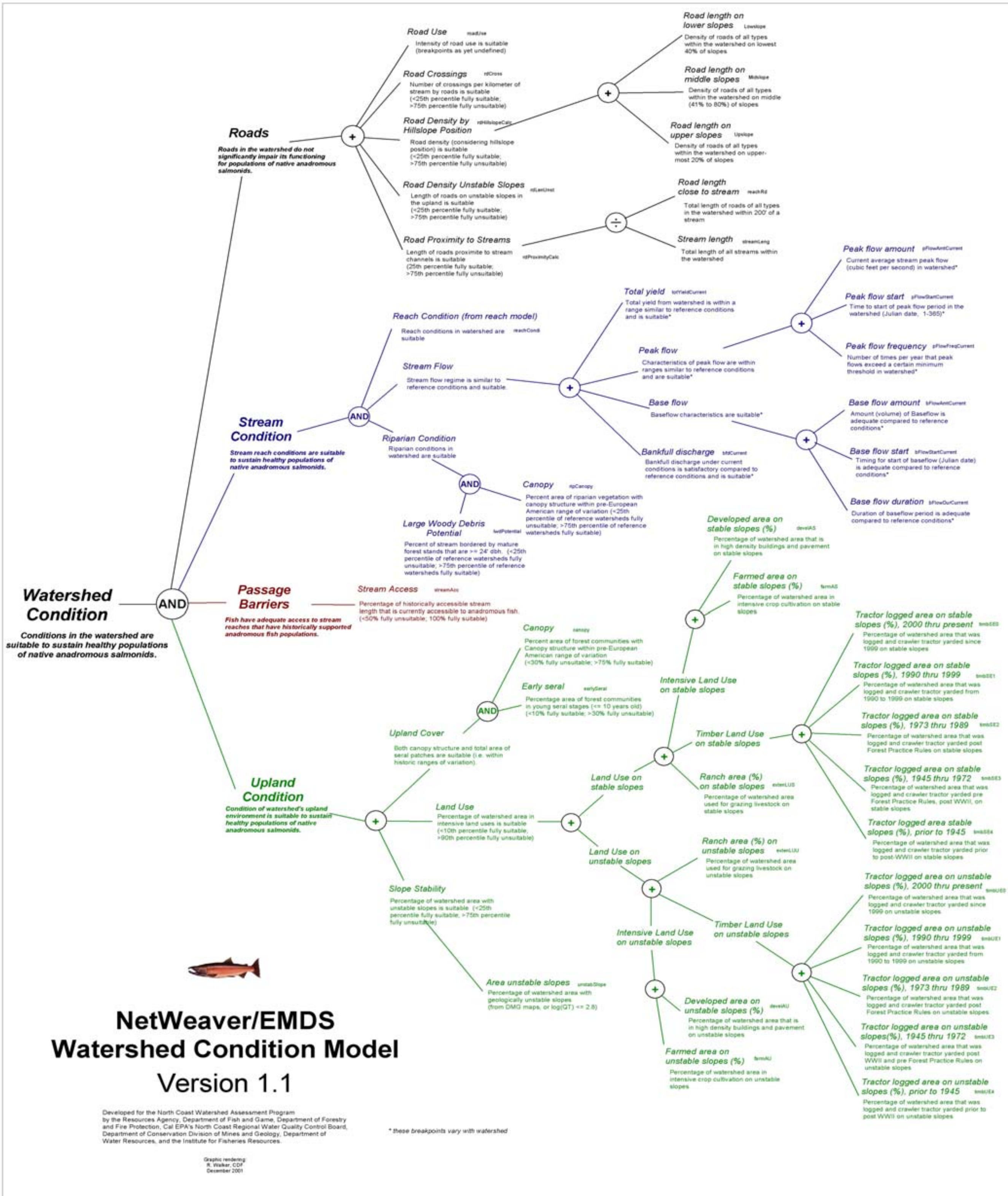
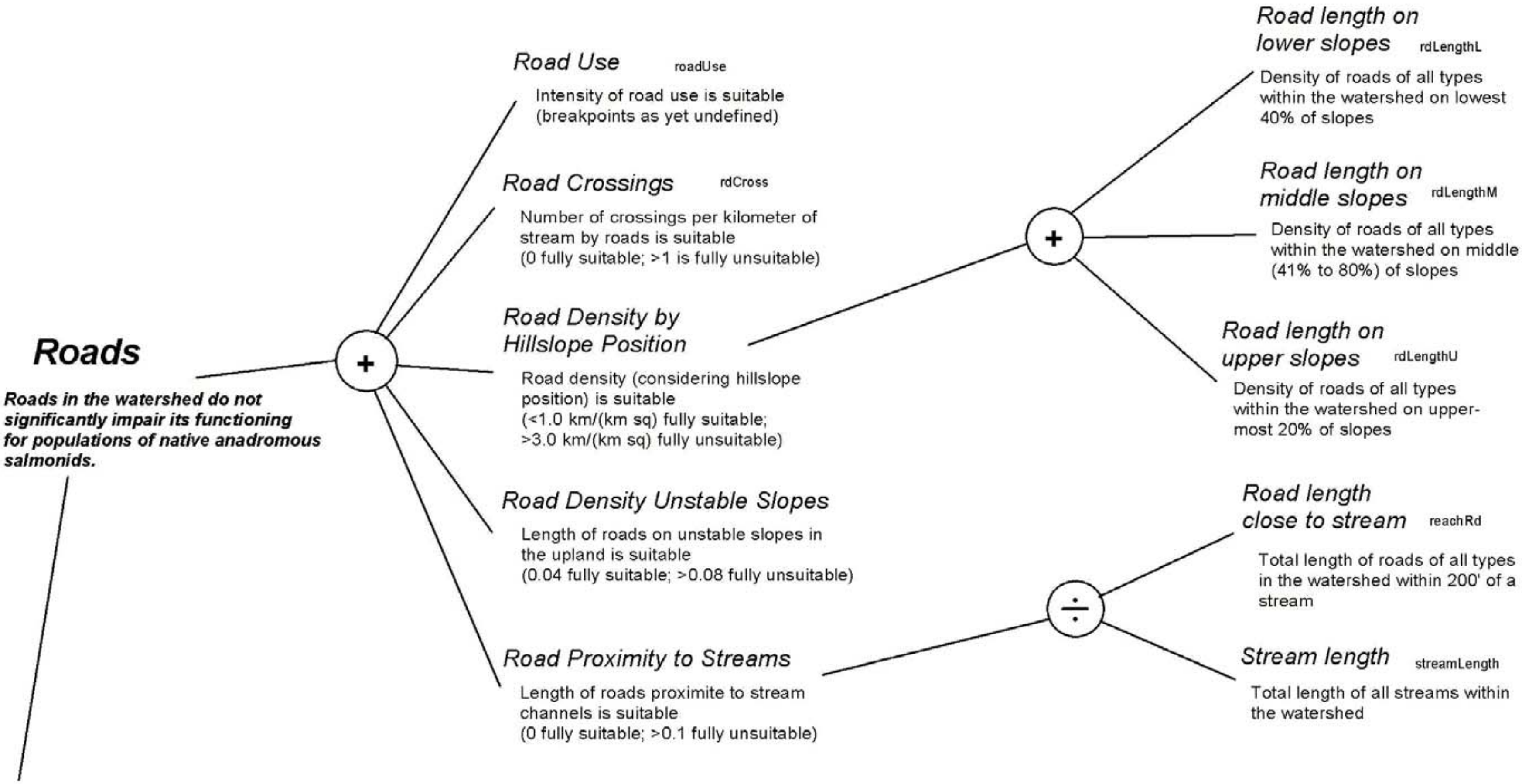


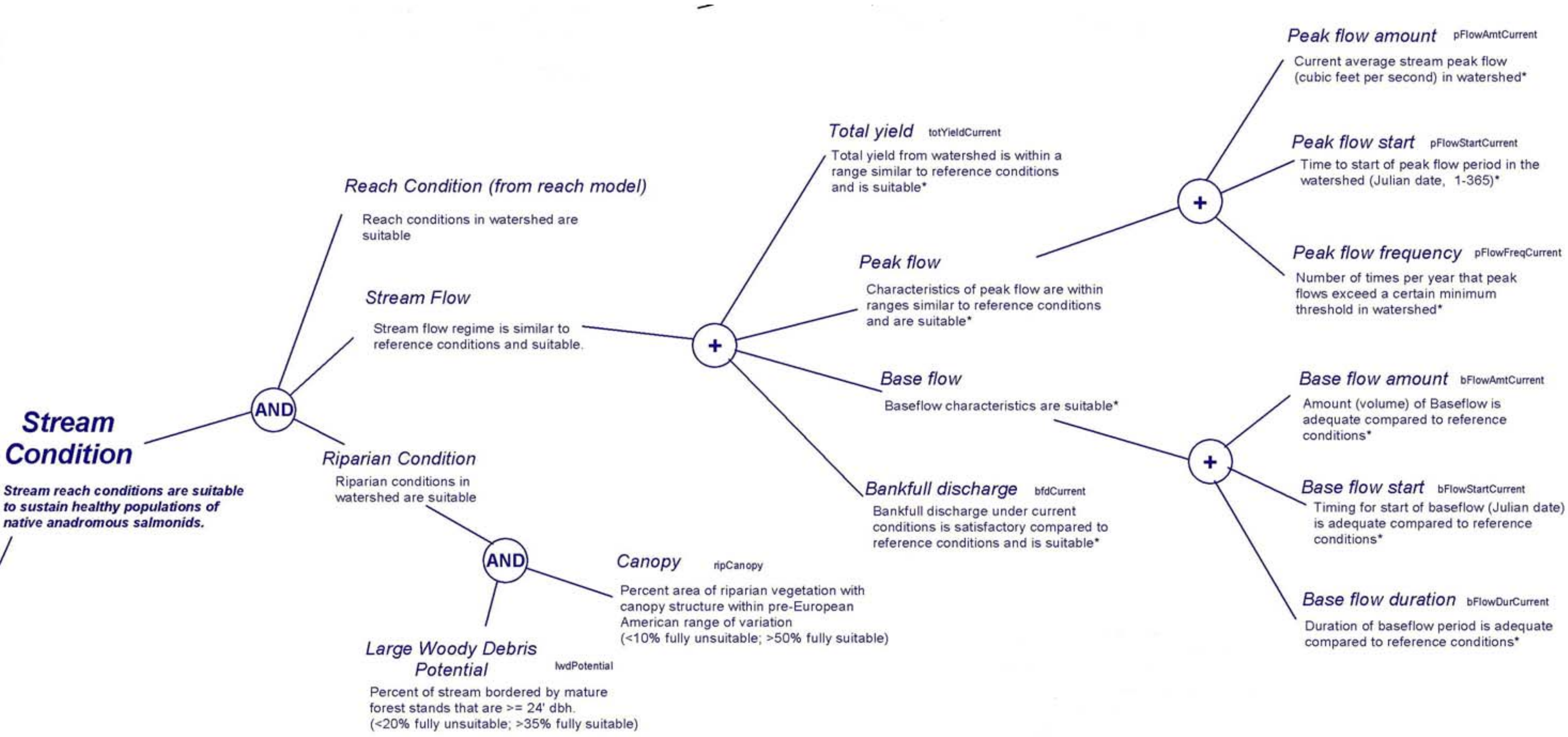
Figure 5: NCWAP EMDS Watershed Condition Model.

Please refer to following pages or EMDS Appendix for a larger view of each dependency network.

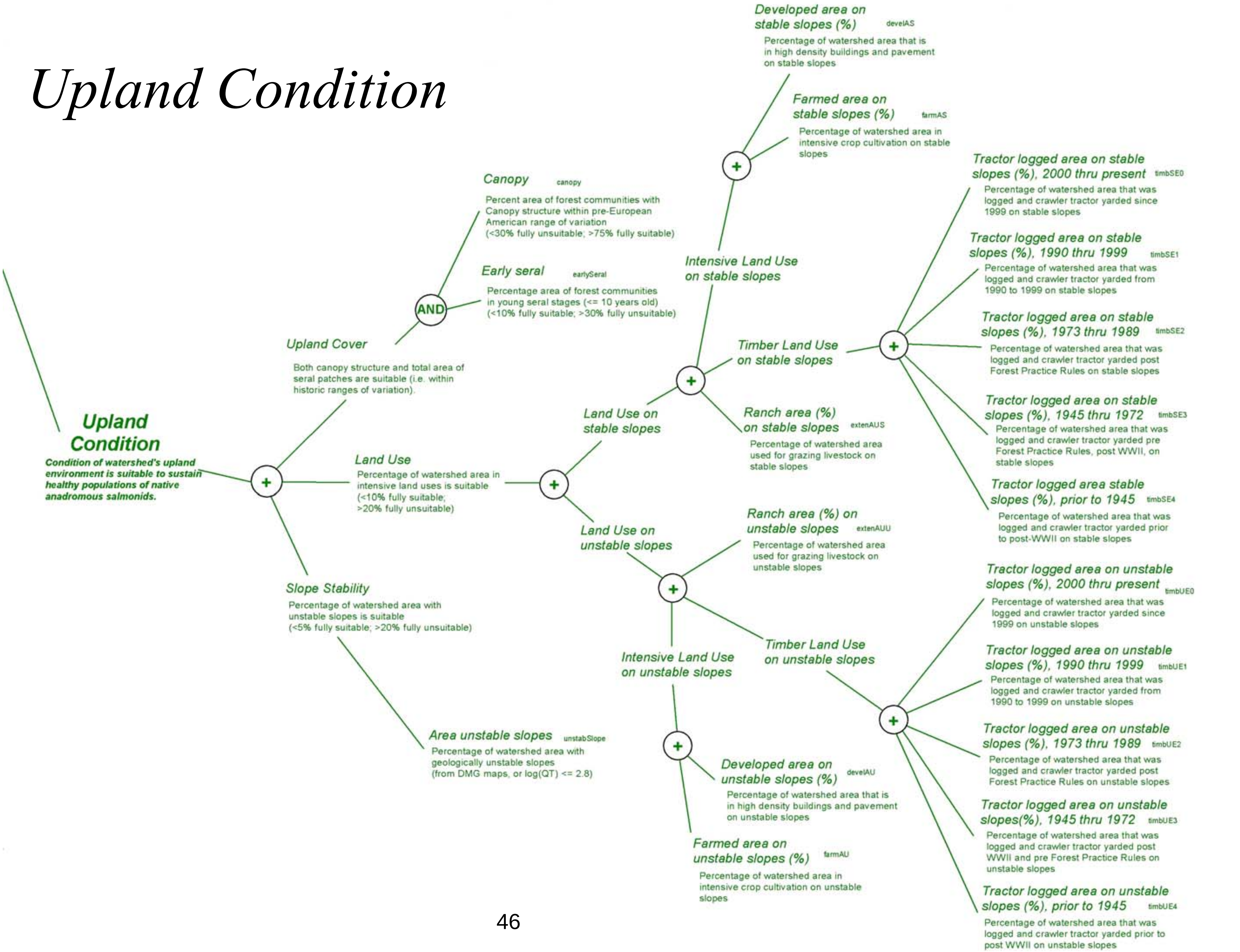
Roads Dependency Network



Stream Condition



Upland Condition



The “ingredients,” or data, needed for the assessment are broken down into categories. To evaluate watershed conditions for salmonids, the model requires data on several general environmental factors. The first branches of the knowledge base network (Figure 6) show that information on upland condition, roads, passage barriers, and stream condition factors are all needed in the watershed assessment. The “AND” decision node (where the factors are combined) means that each of the four general factors must be suitable for the fish for the “watershed is suitable for native salmonids” proposition to be evaluated as completely “true.”

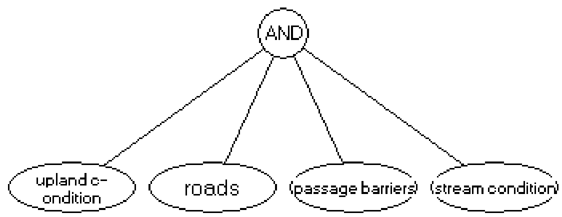


Figure 6: EMDS Knowledge Base Network.

EMDS uses knowledge base networks to assess the condition of watershed factors affecting native salmonids.

Each of the elliptical boxes in Figure 6 on page 47 shows a factor used in the assessment, and lines indicate how they are linked to the ‘AND’ node, where they are compared. In a similar manner, each of the factors can be broken down into the more basic data components that determine it (Figure 4 and Figure 5). For example, in the NCWAP Watershed Condition model the ‘upland condition’ factor consists of a sub-network of more detailed data on land use, land cover (vegetation) and slope stability that determine it. Information in the sub-network that determines land use includes data on developed area, cultivated area, grazed area and area of timber harvests. While the overall watershed condition rating output of the EMDS model is useful to get a rough understanding of the condition of the entire basin, its subbasins, watersheds or sub-watersheds, perhaps the most important part of the model is the more specific information about factors affecting fish that can be gleaned by looking at the finer scales of the dependency networks that contribute to the model’s conclusions.

Wherever there is a proposition in the network, scientists use simple graphs, called “reference curves,” that determine its degree of truth, according to the data and its implications for salmon. Figure 7 shows an example reference curve, where the proposition is “*the stream temperature is suitable for salmon*”. The horizontal axis shows temperature in degrees Fahrenheit, while the vertical is labeled ‘Truth Value’ and ranges from –1 to +1. The line shows what are fully unsuitable temperatures (-1), fully suitable temperatures (+1) and those that are in-between (> -1 and <+1). In this way, similar numeric relations are hypothesized for all propositions in the EMDS evaluation.

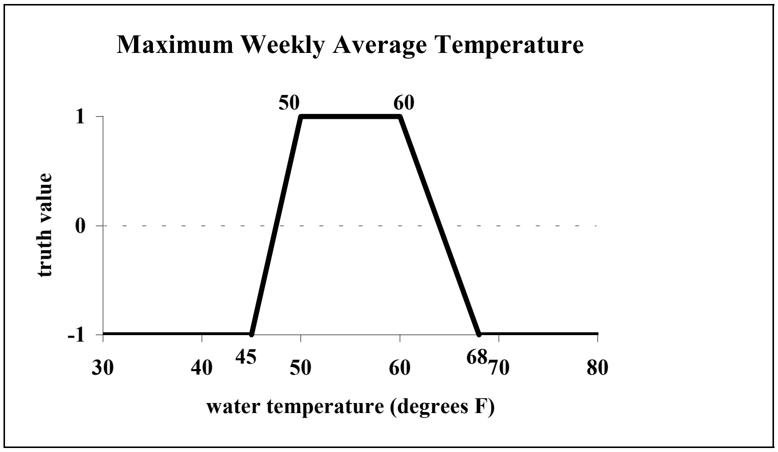


Figure 7: EMDS Reference Curve.

EMDS uses this type of reference curve in conjunction with data specific to a stream reach. This example curve tests the proposition that the stream's water temperature is suitable for salmonids. Break points can be set for specific species, life stage, or season of the year. Curves are dependent upon the availability of data.

For all evaluated propositions in the network, the results are a number between –1 and +1. The number shows the degree to which the data support or refute the 'conditions are suitable' proposition. In all cases a value of +1 means that the proposition is 'completely true', and –1 implies that it is 'completely false', with in-between values indicate 'degrees of truth' (i.e. values approaching +1 being closer to true and those approaching –1 converging on completely untrue). A zero value means that the proposition cannot be evaluated based upon the data available. Breakpoints (where the slope of the function changes) in the Figure 7 example occur at 45, 50, 60 and 68 degrees F. The NCWAP fisheries biologists determined these temperatures by a search of the scientific literature.

Classification system to verbally describe the EMDS truth-values of watershed and stream conditions for salmonids:

Table 2: EMDS Truth Values.

Truth Value	Habitat Component(s) Condition for Salmon
1 (completely true)	fully suitable
1 to 0.5	moderately suitable
0.5 to 0	somewhat suitable
0	undetermined (no data)
0 to -0.5	somewhat unsuitable
-0.5 to -1	moderately unsuitable
-1 (completely false)	fully unsuitable

In EMDS, the data that are fed in to the knowledge base network come from GIS layers stored and displayed in ArcView. Thus many of the GIS data layers developed for the program will be used directly in the watershed condition syntheses. The results can easily be portrayed on maps (Figure 8).

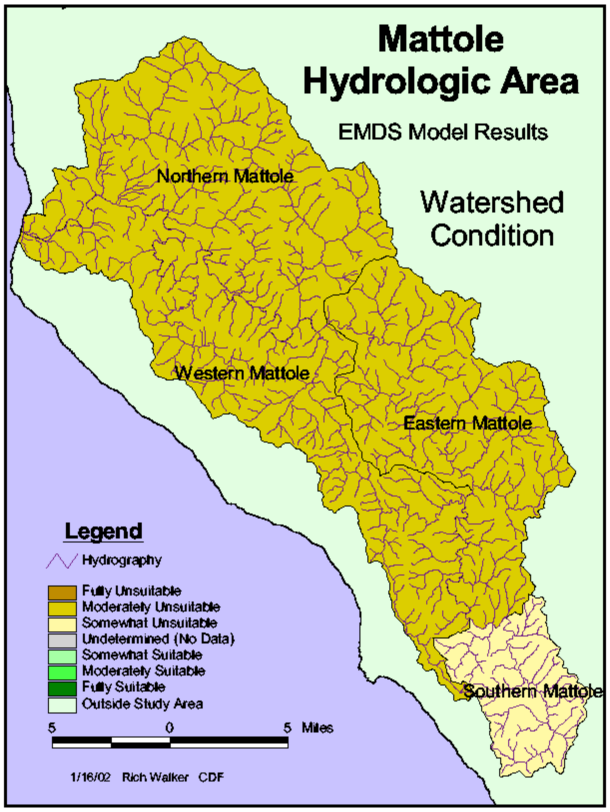


Figure 8: EMDS Graphical Output.

This example illustrates the graphical outputs of an EMDS run. Using incomplete and preliminary data, this demonstration graphic portrays the overall watershed condition ratings for the planning watersheds in the Mattole.

Reference Curves used in NCWAP's Preliminary EMDS Model

Table 2 and Table 3 document the reference curves used in our preliminary EMDS watershed and stream reach models to evaluate conditions for salmonids. In some cases, the reference curves were established on a relative basis (e.g., percentiles of a data range) due to the lack of a scientific or expert judgement basis, rather than using absolute values (e.g., a stream temperature of 45º F). The scientific and resource professional review team will carefully review these reference curves, in addition to the overall structure and content of the model.

Advantages Offered by NetWeaver/EMDS/ArcView Software

The NetWeaver/EMDS/ArcView software offers a number of advantages for use in the NCWAP. At this time no other widely available package allows a knowledge base network to be linked directly with a geographic information system such as ArcView. This link is vital to the production of maps and other graphics reporting the watershed assessments.

The graphs and NetWeaver-based flow diagrams require explicit definition of the conditions salmonids need for the completion of their lifecycle. This formalized and quantified model is now repeatable systematically throughout the assessments of all watersheds. Equally important, the explicit nature of the networks assists open communication to the general public through simple graphics and easily understood flow diagrams.

Another feature of the system is the ease of running alternative scenarios. Scientists and others can test the sensitivity of the assessments to different assumptions about the environmental factors and how they interact, through changing the knowledge-based network and breakpoints. "What-if" scenarios can be run by changing the shapes of reference curves , or by changing the way the data are combined and synthesized in the network.

NetWeaver/EMDS/ArcView tools can be applied to any scale of analysis, from reach specific to entire watersheds. The spatial scale can be set according to the spatial domain of the data selected for use and issue(s) of concern. Alternatively, through additional network development, smaller scale analyses (i.e., subwatersheds) can be aggregated into a large hydrologic unit. With sufficient sampling and data, analyses can even be done upon single or multiple stream reaches.

EMDS and NetWeaver are public domain software (NetWeaver on a trial basis), available to anyone at no cost over the Internet. Although NCWAP will employ EMDS and NetWeaver for watershed synthesis, this is not meant to preclude the use of other knowledge base expert systems, approaches, or models for further exploration of fish-environment relationships.

Management Applications of Watershed Synthesis Results

While EMDS-based syntheses are important tools for watershed assessment, they do not by themselves yield a course of action for restoration and land management. EMDS results require interpretation, and how they are employed depends upon other important issues, such as social and economic concerns. In addition to the accuracy of the expert opinion and knowledge base system constructed, the currency and completeness of the data available for a stream or watershed will strongly influence the degree of confidence in the results. Where possible, external validations of the EMDS model using fish population data and other information should be done.

Table 3: Reference Curve Metrics for EMDS Watershed Condition Model.

Watershed Condition Factor	Reference Curve Metric
Roads	
Road Use	Undefined; no data available
Road Crossings	No. of road crossings/km of streams <25^{th} percentile fully suitable; >75th percentile fully unsuitable
Road Density by Hillslope Position	<25^{th} percentile fully suitable; >75th percentile fully unsuitable; weightings, as detailed below, were used to apply a higher weight to roads lower on the slope.
road length on lower slopes	Density of roads of all types on lower 40% of slopes; weighted 0.6
road length on lower slopes	Density of roads of all types on mid-slope (41-80 % of slope distance); weighted 0.3
road length on upper slopes	Density of roads of all types on upper 20% of slopes; weighted 0.1
Road Density on Unstable Slopes	Length of roads on unstable slopes; <25^{th} percentile fully suitable; >75th percentile fully unsuitable
Road Proximity to Streams	Length of all roads within 200 feet of stream ÷ length of all streams
Stream Condition	
Reach Condition	Input from EMDS Reach Condition Model
Stream Flow	This portion of model currently not used do to lack of data; see appendix for more details
Riparian Conditions	
canopy	Percent area of riparian vegetation within 200 feet of stream and compared to canopy closure on reference streams.
large woody debris potential	Percentage of stream bordered by mature forest stands with quadratic mean diameter of >=24 inches as compared to reference streams.
Fish Passage Barriers	Percentage of historically accessible streams currently accessible to anadromous fish; <50% fully unsuitable; 100% fully suitable
Upland Condition	
Upland Cover	
canopy	Percent area of forest communities with canopy structure within pre-European range of variation; <30% fully unsuitable; >75 % fully suitable
early seral	Percent area in early seral conditions due to stand-replacing natural or human disturbance within past 10 years; <10% fully suitable; >30% fully unsuitable
Land Use	
land use on **stable** slopes	Slope stability defined with SHALSTAB shallow slope stability model; DMG landslide hazard maps will be used when completed
• intensive land use on stable slopes	
--developed areas	Percentage of the watershed area in high density buildings and pavement
--farmed areas	Percentage of watershed area in intensive crop cultivation
• timber harvest on stable slopes	Percentage of watershed area tractor logged weighted by time period; see EMDS appendix for details
• ranch area on stable slopes	Percentage of watershed area used for grazing livestock; estimated based on vegetation type and parcel type
land use on **unstable** slopes	Slope stability defined with SHALSTAB shallow slope stability model; DMG landslide hazard maps will be used when completed
• intensive land use on unstable slopes	
--developed area	Percentage of the watershed area in high density buildings and pavement
--farmed area	Percentage of watershed area in intensive crop cultivation
• timber harvest on unstable slopes	Percentage of watershed area tractor logged weighted by time period; see appendix for details
• ranch area on unstable slopes	Percentage of watershed area used for grazing livestock; estimated based on vegetation type and parcel type
Slope Stability	Slope stability defined with SHALSTAB shallow slope stability model; DMG landslide hazard maps will be used when completed; <25th percentile fully suitable; >75^{th} percentile fully unsuitable.

Table 4: Reference Curve Metrics for EMDS Stream Reach Condition Model.

Stream Reach Condition Factor	*Definition and Reference Curve Metrics*
Water Temperature	
Summer MWAT	Maximum 7-day average summer water temperature $<45^{o}$ F fully unsuitable, 50-60^{o} F fully suitable, $>68^{o}$ F fully unsuitable. Water temperature was not included in current EMDS evaluation.
Riparian Function	
Canopy Density	Average percent of the thalweg within a stream reach influenced by tree canopy. <50% fully unsuitable, ≥85% fully suitable.
Seral Stage	Under development
Vegetation Type	Under development
Stream Flow	Under development
In-Channel Conditions	
Pool Depth	Percent of stream reach with pools of a maximum depth of 2.5, 3, and 4 feet deep for first and second, third, and fourth order streams respectively. ≤20% fully unsuitable, 30 – 55% fully suitable, ≥90% fully unsuitable
Pool Shelter Complexity	Relative measure of quantity and composition of large woody debris, root wads, boulders, undercut banks, bubble curtain, overhanging and instream vegetation. ≤30 fully unsuitable, ≥100 - 300 fully suitable
Pool frequency	Under development
Substrate Embeddedness	Pool tail embeddedness is a measure of the percent of small cobbles (2.5" to 5" in diameter) buried in fine sediments. EMDS calculates categorical embeddedness data to produce evaluation scores between –1 and 1. The proposition is fully true if evaluation sores are 0.8 or greater and -0.8 evaluate to fully false
Percent fines in substrate <0.85mm (dry weight)	Percent of fine sized particles <0.85 mm collected from McNeil type samples. <10% fully suitable, > 15% fully unsuitable. There was not enough of percent fines data to use Percent fines in EMDS evaluations
Percent fines in substrate < 6.4 mm	Percent of fine sized particles <6.4 mm collected from McNeil type samples. <15% fully suitable, >30% fully unsuitable. There was not enough of percent fines data to use Percent fines in EMDS evaluations
Large Woody debris	The reference values for frequency and volume is derived from Bilby and Ward (1989) and is dependant on channel size. See appendix for details Most watersheds do not have sufficient lwd surveys for use in EMDS.
Refugia Habitat	Refugia is composed of backwater pools and side channel habitats and deep pools (>4 feet deep). Not implemented at this time.
Pool to Riffle Ratio	Under development
Width to Depth Ratio	Under development

EMDS syntheses can be used at the basin scale, to show current watershed status. Maps depicting those factors that may be the largest impediments, as well as those areas where conditions are very good, can help guide protection and restoration strategies. The EMDS model also can help to assess the cost-effectiveness of different restoration strategies. By running sensitivity analyses on the effects of changing different habitat conditions, it can help decision makers determine how much effort is needed to significantly improve a given factor in a watershed and whether the investment is cost-effective.

At the project planning level, the model results can help landowners, watershed groups and others select the appropriate types of restoration projects and places (i.e., planning watersheds or larger) that can best contribute to recovery. Agencies will also use the information when reviewing projects on a watershed basis.

The main strength of using NetWeaver/EMDS/ArcView knowledge base software in performing limiting factors analysis is its flexibility, and that through explicit logic, easily communicated graphics, and repeatable results, it can provide insights as to the relative importance of the constraints limiting salmonids in North Coast watersheds. NCWAP will use these analyses not only to assess conditions for fish in the watersheds and to help prioritize restoration efforts, but also to facilitate an improved understanding of the complex relationships among environmental factors, human activities, and overall habitat quality for native salmon and trout.

Limitations of the EMDS Model and Data Inputs

We want to stress that EMDS is an indicative model. That is, it indicates what the quality of watershed or instream conditions are, based on available data and the model structure. It is not intended to provide highly definitive answers, such as a statistically-based process model might. It does provide a reasonable first approximation of conditions through a robust information synthesis approach; however its outputs need to be considered and interpreted in the light of other information sources and the inherent limitations of the model and its data inputs. It also should be clearly noted that EMDS does not assess the marine phase of the salmonid lifecycle, nor does it consider fishery harvest pressures.

The version of the EMDS model used in this report is preliminary (version 1.1) and evolving. It was developed based on the EMDS model developed for use in coastal Oregon, with modifications made on the basis of additional scientific information, standards established in the DFG restoration manual, discussion among NCWAP staff, and an EMDS workshop which included participants from the NCWAP team, other state and federal agency staff, and scientists. The University of California conducted this workshop. As noted above, NCWAP and UC are currently developing a follow-up team of scientists and practitioners to review help improve the current version of the model. It is anticipated that this process will be completed in time to allow the model improvements to be incorporated into the final draft of this report, which we expect to release in May 2002.

NCWAP staff has identified a number of model or data elements needing attention and improvement in the next version. These include:

- integration of stream temperature information into the model;
- development of fish passage barrier information for inclusion in the model;
- development of stream flow information for inclusion in the model;
- examination of the "operators" that combine the various branches of the model (e.g., "and" operators that pass forward the lowest value at a node versus "+" operators that pass the average value)
- use of residual versus maximum pool depth in the stream reach portion of the model;
- modification of canopy density standards for wide streams;
- incorporation of updated and improved vegetation data that will be available in February 2002;
- completion of quality control evaluation of several data layers;
- adjusting the model to better reflect differences between stream mainstems and tributaries;

- substituting DMG slope stability information (when completed) for slope stability estimates determined with the SHALSTAB shallow slope stability model.

The NCWAP team will address these limitations, to the extent possible, before the final draft of the Mattole River assessment report is completed in May 2002.